National Transportation Safety Board

Washington, D.C. 20594

Safety Recommendation

Date: September 17, 2002

In reply refer to: A-02-26 through -32

Honorable Marion C. Blakey
Administrator
Federal Aviation Administration
Washington, D.C. 20591

On November 20, 2000, about 1222 eastern standard time,[1] a flight attendant/purser was killed during an emergency evacuation of American Airlines flight 1291, an Airbus Industrie A300B4-605R (A300), N14056, at Miami International Airport (MIA), Miami, Florida. The airplane was pressurized until the flight attendant/purser opened the left front (1L) emergency exit door; he was then forcibly ejected from the airplane. There were 133 persons on board. During the emergency evacuation, in addition to the 1 flight attendant/purser who was killed, 3 passengers sustained serious injuries; 18 passengers and 1 flight service director[2] sustained minor injuries; and the 2 pilots, 6 flight attendants, 1 off-duty flight attendant, 1 flight service director, and the remaining 100 passengers reported no injuries. The airplane sustained minor damage.[3]

The flight was operating as a 14 *Code of Federal Regulations* Part 121 scheduled international passenger flight. Visual meteorological conditions prevailed, and an instrument flight plan was filed. The flight departed MIA for Port Au Prince International Airport, Haiti, and had been airborne for about 8 minutes when the flight crew encountered a problem with the automatic pressurization system. The captain later stated to National Transportation Safety Board investigators that the automatic cabin pressurization controllers would not control cabin pressure when the airplane was climbing through 16,000 feet and that the electronic centralized airplane monitor (ECAM) display[4] indicated that the forward outflow valve[5] was fully open.[6] The captain

[1] All times in this letter are eastern standard time, based on a 24-hour clock.

[2] Flight service directors are language translators who are assigned to selected flights to assist flight attendants in communicating with passengers. Although flight service director training requires that they observe flight attendant emergency procedures training, they are not qualified as flight attendants.

[3] The description for this accident, MIA01FA029, can be found on the National Transportation Safety Board's Web site at <http://www.ntsb.gov>.

[4] The ECAM display is a cathode ray tube screen located in the cockpit. The system is automatic and displays messages and system diagrams to pilots. It provides operational assistance for both normal and abnormal airplane system situations.

[5] The two outflow valves open and close during flight and on the ground to maintain control of cabin pressurization.

[6] At this point in flight, the valves would normally be over halfway closed. Postaccident examination of the airplane by the Safety Board's Systems Group revealed that insulation blankets partially blocked the forward outflow valve and almost fully blocked the aft outflow valve.

stated that when he called up the pressurization system ECAM display, the outflow valve positions were displayed in amber, indicating that an outflow valve was over 95 percent open. The cabin altitude was climbing at a rate of 2,000 feet per minute, and the cabin altitude indicator showed 7,000 feet. The captain decided to operate the pressurization system in the manual mode and, about 11 minutes after departure, indicated to air traffic control (ATC) that the flight would return to MIA. At that point, the pilots began performing the American Airlines A300[7] Cabin Pressurization Manual Control Checklist,[8] which is contained in the American Airlines A300 operating manual.

The captain stated to Safety Board investigators that during the return to MIA, the flight attendant call chimes sounded erratically, and the lavatory smoke detectors[9] sounded continually. The flight attendants also reported that the call chimes at the flight attendant telephone stations sounded intermittently and that the white CAPT CALL (captain call) lights illuminated. They stated that when they answered the phones (expecting that a flight crewmember was calling), they did not hear anything. One flight attendant stated that she tried to reset her phone, but it continued to ring. Passengers and cabin crewmembers complained about pressure in their ears. About 3 minutes before landing, the captain declared an emergency to ATC and requested that aircraft rescue and firefighting (ARFF) personnel stand by for the landing. After the airplane landed at MIA, ARFF personnel checked the exterior of the airplane and reported no signs of fire. The cockpit voice recorder (CVR) indicates that a flight attendant reported smelling smoke to the flight crew. The captain indicated to Board investigators that he observed the illumination of a "cargo loop light"[10] on the cockpit overhead panel. The captain then ordered an emergency evacuation of the airplane, and the American Airlines A300 Ground Evacuation Checklist[11] was performed.

The flight attendants heard the sounding of the evacuation signaling system and attempted to open the emergency exit doors to begin the emergency evacuation but were having difficulty doing so. A flight attendant reported to the flight crew that the doors would not open. While the flight attendant/purser was struggling to open the 1L emergency exit door of the airplane, the door suddenly burst open, and he was forcibly ejected onto the ramp and was killed. Preliminary findings from the investigation revealed that excess air pressure inside the cabin caused the door to burst open when the flight attendant/purser attempted to open it. This accident investigation is ongoing.[12]

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[7] All A300 airplanes that American Airlines operates are A300-600 airplanes.

[8] The American Airlines A300 Cabin Pressurization Manual Control Checklist is similar to that of Airbus. The entire checklist cannot be performed at one time; rather, pilots must initiate the checklist and then complete it later in flight. According to the accident captain, he did not perform all of the items in the Cabin Pressurization Manual Control Checklist because of his other priorities at the time, including addressing the smoke indications and landing the airplane.

[9] No evidence of fire in any of the lavatories was found in the Safety Board's postaccident examination of the airplane.

[10] Illumination of a light on the CARGO COMPT SMOKE DET panel may indicate a fire in the cargo compartment. No evidence of fire was found in the Safety Board's postaccident examination of the airplane.

[11] The American Airlines A300 Ground Evacuation Checklist, which is contained in the American Airlines A300 operating manual, is similar to the Airbus A300-600 On Ground/Emergency Evacuation Checklist.

[12] The Safety Board notes that the flight crew failed to select the Cabin Vertical Speed Control switch to the UP position, which would have opened the outflow valves when the pressurization system was in the manual mode and would likely have depressurized the airplane. On May 8, 2001, the Board issued Safety Recommendations A-01-16

During the Safety Board's investigation of this accident, a similar accident occurred on October 20, 2001. In that accident, one flight attendant was killed and another flight attendant was seriously injured during the deplaning of TunisAir flight TARB631, an Airbus A300-605R, Tunisian registration TS-IPA, at Djerba Airport, Djerba, Tunisia. The flight was conducted as a scheduled international passenger flight from Geneva, Switzerland, to Djerba. There were 2 flight crewmembers, 10 cabin crewmembers, and 134 passengers on board.

According to Airbus, on the flight to Geneva before the October 20, 2001, accident flight, the flight crew received an excessive cabin altitude warning and then placed the pressurization system in manual mode. The airplane landed safely at Geneva, and maintenance personnel inspected the airplane and found no anomalies. The airplane was then dispatched on the accident flight from Geneva to Djerba.

According to Airbus, while the flight was enroute to Djerba, the flight crew again received an excessive cabin altitude warning and immediately placed the pressurization system in manual mode. The remainder of the flight and the landing at Djerba were uneventful. The airplane was parked at Djerba, and the engine bleed air was still turned on, allowing pressurized air into the airplane. While an air stair was being positioned to the 2L door of the airplane, a flight attendant attempted to open the 2L door. Excessive cabin pressure caused the door to burst open, and the flight attendant who opened the door was ejected and sustained serious injuries. A flight attendant who was standing near the flight attendant who opened the door was also ejected from the airplane and was killed.

The Safety Board has identified several safety issues relating to these accidents that require the FAA's attention.

Cabin Altitude Gauge

Airplane pressurization systems can be operated in automatic and manual modes. The manual mode of operation is used on the Airbus A300-600 airplane when the automatic mode becomes inoperative and allows the flight crew to manually operate the electric motors that control the outflow valves. The A300 pressurization system includes the following three gauges that indicate pressurization information to the flight crew when the airplane's pressurization

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through -22 to the Federal Aviation Administration (FAA) regarding information contained in the Airbus Industrie A300-600 operating manual and checklists (Safety Recommendations A-01-16, -17, and -20) and A300-600 operators' operating manuals, checklists, and training programs (Safety Recommendations A-01-18, -19, -21, and -22). Safety issues included the adequacy of information regarding depressurization of the airplane when the pressurization system is being operated in the manual mode; the need for the flight crew to verify that the cabin differential pressure is 0 pounds per square inch (psi) before signaling the flight attendants to begin an emergency evacuation; and the need for the flight crew to verify that the cabin differential pressure is 0 psi before permitting the flight attendants or gate agents to open the cabin doors. In a January 23, 2002, letter to the FAA, the Board classified Safety Recommendations A-01-16, -17, and -20 "Open—Acceptable Response" and Safety Recommendations A-01-18, -19, -21, and -22 "Open—Unacceptable Response."

system is being operated in the manual mode:[13] the cabin altimeter,[14] the cabin vertical speed indicator, and the cabin differential pressure indicator.[15]

The cabin altimeter is located on the cockpit overhead panel and is marked with values from 20,000 to -5,000 feet. (Figure 1 shows a cabin altimeter from an Airbus A300 airplane.) Unmarked space separates the -5,000-foot mark and the 20,000-foot mark on the gauge. The needle on the gauge moves clockwise into the positive range to indicate higher cabin altitudes as the cabin pressure decreases and moves counterclockwise to indicate lower cabin altitudes as the cabin pressure increases. The investigation determined that when cabin pressure increases such that the cabin altitude is less than -5,000 feet, the cabin altimeter needle moves counterclockwise through the negative altitude range, including past the -5,000 mark, through the unmarked area, and into the highest end of the positive altitude range. There are no mechanical stops on the cabin altimeter that restrict the needle to the marked areas of the gauge and prevent the needle from traveling to the positive altitude range when the cabin altitude is actually beyond -5,000 in the negative range.

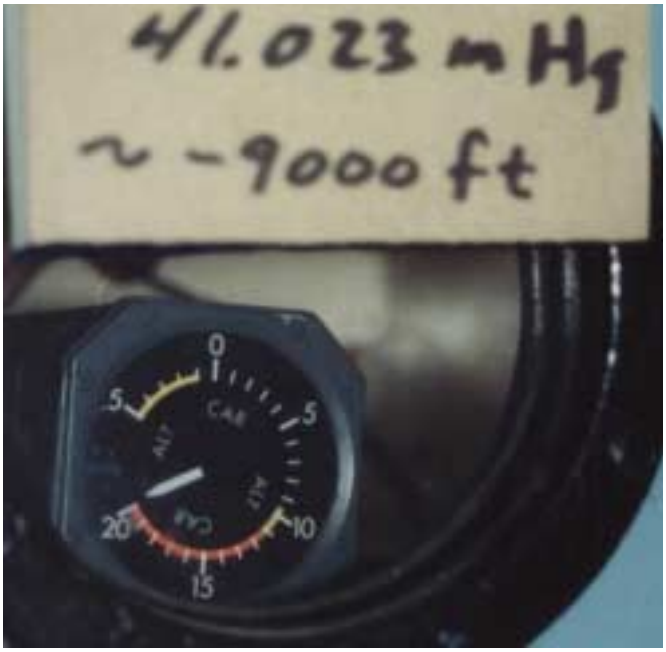

Figure 1. Cabin altimeter from an Airbus A300 airplane.

The investigation determined that at one point during American Airlines flight 1291's approach to MIA, the cabin altitude reached -12,100 feet. Specifically, at 1212:31, the CVR recorded a sound similar to a lavatory smoke detector. During postaccident testing of the

[13] When the airplane's pressurization system is being operated in the automatic mode, the Engine Indication and Crew Alerting System (EICAS) displays the same information that these three gauges display. However, when the pressurization system is being operated in the manual mode, the EICAS no longer displays this information.

[14] The cabin altimeter is the primary gauge for the pressurization system when it is being operated in manual mode.

[15] The cabin vertical speed indicator and the cabin differential pressure indicator are located directly below the cabin altimeter in the cockpit. The cabin vertical speed indicator displays the rate of change of the cabin altitude, while the cabin differential pressure indicator displays the difference in pressure between the cabin and the atmosphere.

lavatory A smoke detector,[16] its alarm was triggered with no smoke present[17] at a pressure level of 22.28 pounds per square inch absolute (psia),[18] which corresponds to a cabin altitude of -12,100 feet. However, because the cabin altimeter's negative range stops at -5,000 feet, the -12,100-foot cabin altitude would have registered on the cabin altimeter in the high end of the positive range, indicating a cabin altitude of approximately 19,000 feet. This would have presented the flight crew with a misleading indication of a high cabin altitude (indicating low cabin pressure) when, in fact, the cabin was pressurized well above ambient pressure. This high cabin altitude indication would likely have confused the flight crew because it would have appeared that the actions that they had taken to manually pressurize the airplane after recognizing the malfunctioning pressurization system were not being properly reflected in the cabin altimeter reading.[19]

The Safety Board is concerned that the cabin altimeter gauges on all A300 airplanes may present flight crews with misleading information about the airplane's cabin altitude and pressure, particularly when the pressurization system is malfunctioning and is being operated in the manual mode. The Board notes that if the cabin altitude were displayed in a digital display as opposed to a mechanical gauge, the display would likely have indicated the accurate cabin altitude of -12,100 feet. The Board further notes that a broader range of values on the cabin altimeter gauge (from -20,000 to 20,000 feet, as opposed to -5,000 to 20,000 feet) would also likely have resulted in an accurate indication of cabin altitude to the flight crew. Therefore, the Safety Board believes that the FAA should require that the cabin altimeter gauges on all Airbus Industrie A300 airplanes be modified to ensure that they will not give flight crews misleading indications about cabin altitude and pressure, particularly when the pressurization system is being operated in the manual mode. This could be accomplished either by the replacement of the gauge with a digital display, by the expansion of the values on the existing gauge design, or by other means.

The Safety Board is aware of a similar overpressurization event that occurred on December 3, 2000, on a Boeing 737 (737) airplane. During that event, the flight crew was presented with a 20,000-foot cabin altitude reading on the cabin altimeter (indicating low cabin pressure) at 7,000 feet during descent when, in fact, the cabin was overpressurized. The flight crew, believing that the cabin altitude reading was accurate, selected the manual mode of the pressurization system[20] and commanded the outflow valves to the closed position to correct the (perceived) high cabin altitude.[21] In response to these adjustments, the flight crew saw the cabin altimeter indicate a lower cabin altitude (which was the desired response), but the cabin actually continued to overpressurize. The flight crew circled the destination airport while troubleshooting

[16] The investigation determined that, because lavatory A is immediately adjacent to the cockpit, the sounding of its smoke detector was most likely what the CVR recorded.

[17] The Safety Board will discuss the operation of the lavatory smoke detectors later in this letter.

[18] Psia is pressure as measured from a vacuum condition.

[19] The CVR recording indicates that the flight crew discussed confusing cabin altitude readings for approximately 3.5 minutes before the smoke detector alarm was recorded.

[20] The flight crew indicated that it selected the manual pressurization mode since the automatic systems were not able to control the cabin pressure adequately.

[21] Commanding the outflow valves closed drives a high cabin altitude (low pressure) towards a lower cabin altitude (higher pressure).

the problem; however, the cabin pressure did not equalize with the ambient pressure until after the aircraft landed and the outflow valves opened.[22]

The Safety Board notes that if the cabin altitude were displayed on a digital display or if the existing cabin altimeter gauge design had a broader range of values, the flight crew would likely have gotten an accurate cabin altitude reading. The Board is concerned that the potential to misinterpret an overpressure condition as a low pressure condition exists on all aircraft that do not have cabin altimeters that accurately display cabin altitude, particularly when the pressurization system is being operated in the manual mode. Therefore, the Safety Board believes that the FAA should conduct a survey of transport-category aircraft to determine which are equipped with cabin altimeters that are capable of displaying indications beyond the marked ranges of the gauge and require that the cabin altimeter gauges on those airplanes be modified to ensure that they will indicate the correct cabin altitude to the flight crew, particularly when the pressurization system is being operated in the manual mode. This could be accomplished either by the replacement of the gauge with a digital display, by the expansion of the values on the existing gauge design, or by other means.

Lavatory Smoke Alarms

The captain reported that during the November 20, 2000, accident flight, the lavatory smoke detector alarms sounded continually while the aircraft was returning to MIA. On final approach, the loop B cargo compartment smoke detector indicated a loop fault.[23] The flight crew indicated in postaccident interviews that it ordered the emergency evacuation because it believed that the smoke detector alarms, in conjunction with the cargo compartment loop light, indicated a possible fire.

The investigation revealed that the Airbus A300 lavatory and cargo compartment smoke detectors are ionization-type detectors whose sensitivity is affected by ambient pressure. When the ambient pressure level elevates beyond a certain point, which varies with each detector, the lavatory and cargo compartment smoke detectors sound their alarms when no smoke is present. The Safety Board reviewed the qualification requirements for aircraft smoke detectors and found that Technical Standard Order (TSO)-C1c, "Cargo Compartment Fire Detection Instruments," which was issued by the FAA on July 10, 1987, applies to aircraft cargo compartment smoke detectors on all transport-category aircraft; however, no TSO exists for aircraft lavatory smoke detectors on transport-category aircraft. The TSO for the cargo compartment smoke detectors contains requirements for proper operation at elevated pressure levels up to 24.5 psia. Therefore, a properly functioning cargo compartment smoke detector would likely not provide an erroneous indication of smoke or fire at elevated pressure levels, so long as those levels are lower than those specified by the TSO.[24]

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[22] The reason for the opening of the outflow valves after landing could not be determined. Neither the 737 nor the A300 has a design feature that automatically opens the outflow valves upon landing when the pressurization system is in the manual mode.

[23] The illumination of a loop fault light indicates that one smoke detector (out of two in the loop) has triggered its alarm, but the other detector has not and that a fire may (or may not) exist in the cargo compartment. The cargo compartment smoke detector does not sound an alarm if one loop fault light is lit.

[24] Although the TSO for the cargo compartment smoke detector requires proper operation of the smoke detector at pressure levels above those experienced on the accident flight, the accident airplane's cargo compartment smoke

The aural and visual false alarms generated by the lavatory smoke detectors on the November 20, 2000, accident flight added unnecessarily to the workload of the flight and cabin crew and caused the flight crew to order an emergency evacuation. The Safety Board is concerned that unnecessary emergency evacuations may be conducted if lavatory (and other ionization-type) smoke detectors are activated at higher pressure levels in the absence of smoke. This could be avoided if they were held to the same technical standards as cargo compartment smoke detectors. Therefore, the Safety Board believes that the FAA should require that all ionization-type smoke detectors (including lavatory smoke detectors) on newly manufactured transport-category aircraft adhere to the technical standards in TSO-C1c for cargo compartment smoke detectors. Further, the Safety Board believes that the FAA should require that, within 5 years, all ionization-type smoke detectors (including lavatory smoke detectors) on existing transport-category aircraft meet the same technical standards in TSO-C1c for cargo compartment smoke detectors.

The investigation also revealed that neither the Airbus nor the American Airlines A300 flight crew operating manual contains information about the possibility of elevated pressure levels triggering the sounding of ionization-type smoke detectors. If the flight crew had known about the possibility of smoke detectors sounding at higher pressure levels, the flight crew may have been able to consider this information in their troubleshooting actions. The Board does not want to diminish the importance of taking immediate action in response to a fire warning of any type. However, if pilots of all aircraft with ionization-type smoke detectors were informed of the potential for false alarms in overpressure situations, they might be able to quickly determine whether an alarm is due to smoke or an overpressurization event. Therefore, the Safety Board believes that, until all existing aircraft have been retrofitted with ionization-type smoke detectors that are TSO-compliant, the FAA should require that the operating manuals of all transport-category aircraft, including the Airbus Industrie A300, that are equipped with ionization-type smoke detectors (including lavatory smoke detectors) that are not TSO-compliant state that overpressure conditions may lead to false alarms from those detectors. However, it should remain clear that immediate action in response to the fire warning is necessary until an overpressurization condition is verified.

According to the November 20, 2000, accident flight's cabin crew, confusion was caused by the multiple lights and audible signals generated by the lavatory smoke detectors when their alarms were triggered during the return to MIA. The investigation determined that the following lights and audible signals were generated on the November 20, 2000, accident flight (and are typically generated on the A300 upon the triggering of a lavatory smoke alarm):

- The red light on the smoke detector was illuminated;
- A repetitive audible tone was emitted from the smoke detector;
- A red warning light on the lavatory wall blinked;
- The red SMOKE LAV (smoke lavatory) warning light on the forward flight attendant's panel blinked;

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detector was malfunctioning and caused the loop light to illuminate on the CARGO COMPT SMOKE DET panel in the cockpit. The Safety Board has not determined why the cargo compartment smoke detector malfunctioned in this accident, but it appears to be an isolated incident.

- The red SMOKE LAV warning light on the aft flight attendant's panel blinked;
- A repetitive HI/LO (high/low) chime was broadcast in the cabin;
- The white CAPT CALL lights at the flight attendant telephone stations came on;
- The green lights on the flight attendant telephone station keypads came on;
- The area red call lights on the ceilings in the aisles blinked;
- The amber area call lights on the ceilings in the aisles blinked, indicating in which lavatory the alarm was located.

The investigation revealed that some of the visual signals generated by the lavatory smoke alarm were not helpful in directing the cabin crew to the source of the alarm. Specifically, the white CAPT CALL lights and the green keypad illuminations on the flight attendant telephone stations are indications used for other purposes, including indicating a call from the captain to the flight attendants. Generated by the lavatory smoke alarm, these illuminations led the cabin crew to believe that the flight crew was trying to call rather than alert the cabin crew to potential smoke in a lavatory. The cabin crewmembers were distracted from their duties during the return to MIA when they attempted to answer the (perceived) call from the flight crew and found that the flight crew was not on the telephone. If a fire had existed on the accident airplane, the confusion generated by the CAPT CALL and green keypad illuminations could have wasted valuable time. The Safety Board is concerned that the CAPT CALL and the green keypad illuminations associated with the lavatory smoke detector alarm function on Airbus A300 airplanes do not provide relevant information about a potential fire hazard and could potentially distract flight and cabin crews from their duties during flight or during an evacuation. Therefore, the Safety Board believes that the FAA should require that all operators of Airbus Industrie A300 airplanes eliminate the CAPT CALL light and the green keypad illuminations from the lavatory smoke detector alarm function. Further, the Safety Board believes that the FAA should require that, on all future Airbus Industrie A300 airplanes, the CAPT CALL light and the green keypad illuminations are not included in the lavatory smoke detector alarm function.

Therefore, the National Transportation Safety Board recommends that the Federal Aviation Administration:

> Require that the cabin altimeter gauges on all Airbus Industrie A300 airplanes be modified to ensure that they will not give flight crews misleading indications about cabin altitude and pressure, particularly when the pressurization system is being operated in the manual mode. This could be accomplished either by the replacement of the gauge with a digital display, by the expansion of the values on the existing gauge design, or by other means. (A-02-26)

> Conduct a survey of transport-category aircraft to determine which are equipped with cabin altimeters that are capable of displaying indications beyond the marked ranges of the gauge and require that the cabin altimeter gauges on those airplanes be modified to ensure that they will indicate the correct cabin altitude to the flight crew, particularly when the pressurization system is being operated in the manual mode. This could be accomplished either by the replacement of the gauge with a digital display, by the expansion of the values on the existing gauge design, or by other means. (A-02-27)

Require that all ionization-type smoke detectors (including lavatory smoke detectors) on newly manufactured transport-category aircraft adhere to the technical standards in Technical Standard Order C1c for cargo compartment smoke detectors. (A-02-28)

Require that, within 5 years, all ionization-type smoke detectors (including lavatory smoke detectors) on existing transport-category aircraft meet the same technical standards in Technical Standard Order C1c for cargo compartment smoke detectors. (A-02-29)

Until all existing aircraft have been retrofitted with ionization-type smoke detectors that are technical standard order (TSO)-compliant, require that the operating manuals of all transport-category aircraft, including the Airbus Industrie A300, that are equipped with ionization-type smoke detectors (including lavatory smoke detectors) that are not TSO-compliant state that overpressure conditions may lead to false alarms from those detectors. (A-02-30)

Require that all operators of Airbus Industrie A300 airplanes eliminate the CAPT CALL light and the green keypad illuminations from the lavatory smoke detector alarm function. (A-02-31)

Require that, on all future Airbus Industrie A300 airplanes, the CAPT CALL light and the green keypad illuminations are not included in the lavatory smoke detector alarm function. (A-02-32)

Former Chairman Blakey, Vice Chairman CARMODY, and Members HAMMERSCHMIDT, GOGLIA, and BLACK concurred in these recommendations.

Original Signed

By: Carol J. Carmody
Acting Chairman